Searching for hyperspectral optical proxies to aid Chesapeake Bay resource managers in the detection of poor water quality

Shellfish aquaculture is a growing industry in the Chesapeake Bay. As population grows near the coast, extreme weather events cause a greater volume of pollutant runoff from impervious surfaces and agricultural lands. Resource managers who monitor shellfish beds need reliable information on a variety of water quality indicators at higher frequency than is possible through field monitoring programs and at a higher level of detail than current satellite products can provide. Although many factors causing degraded water quality that can impact human health are not currently discernable by traditional multispectral techniques, hyperspectral imagery offers a new opportunity to detect phytoplankton communities associated with harmful algal blooms and biotoxin production. Together with resource managers in their routine monitoring of sites around the bay from small boats, we have been exploring remotely sensed optical proxies for the detection of harmful algal blooms and sewage. Early warning by remote sensing could guide sampling and improve the efficiency of shellfish bed closures, ultimately improving health outcomes for humans and animals. An extensive network of routine sampling by Chesapeake Bay Program managers makes this is an ideal location to develop and test future satellite data products to support management decisions. Next generation hyperspectral measurements from the future Plankton Aerosol Cloud ocean Ecosystem (PACE) mission at nearly daily frequency, combined with the potential of higher spatial resolution from the Surface Biology and Geology (SBG) observing system recommended in the recent Decadal Survey, along with high frequency observations from the newly selected Geostationary Littoral Imaging and Monitoring Radiometer (GLIMR) Earth Venture Instrument make this a critical time for defining the needs of the aquaculture and resource management community to save lives, time, and money.

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Authors:
Stephanie Schollaert Uz[1], Rossana Del Vecchio[2], Shannon McDonnell[2], John McKay[3]
Neil Blough[2]
(1)NASA Goddard Space Flight Center, Greenbelt, MD, United States, (2)University of Maryland, College Park, MD, United States, (3)Maryland Department of Environment, Shellfish Monitoring Division, Annapolis, MD, United States

CP14D-1100

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Stephanie Schollaert Uz[1], Rossana Del Vecchio[2†], Shannon McDonnell[2], John R. McKay[3], Neil Blough[2]

[1]NASA Goddard Space Flight Center, Greenbelt, MD [2]University of Maryland, College Park, MD, [†]Deceased, [3]Maryland Department of Environment, Annapolis, MD

Corresponding author: <stephanie.uz@nasa.gov>

Overview

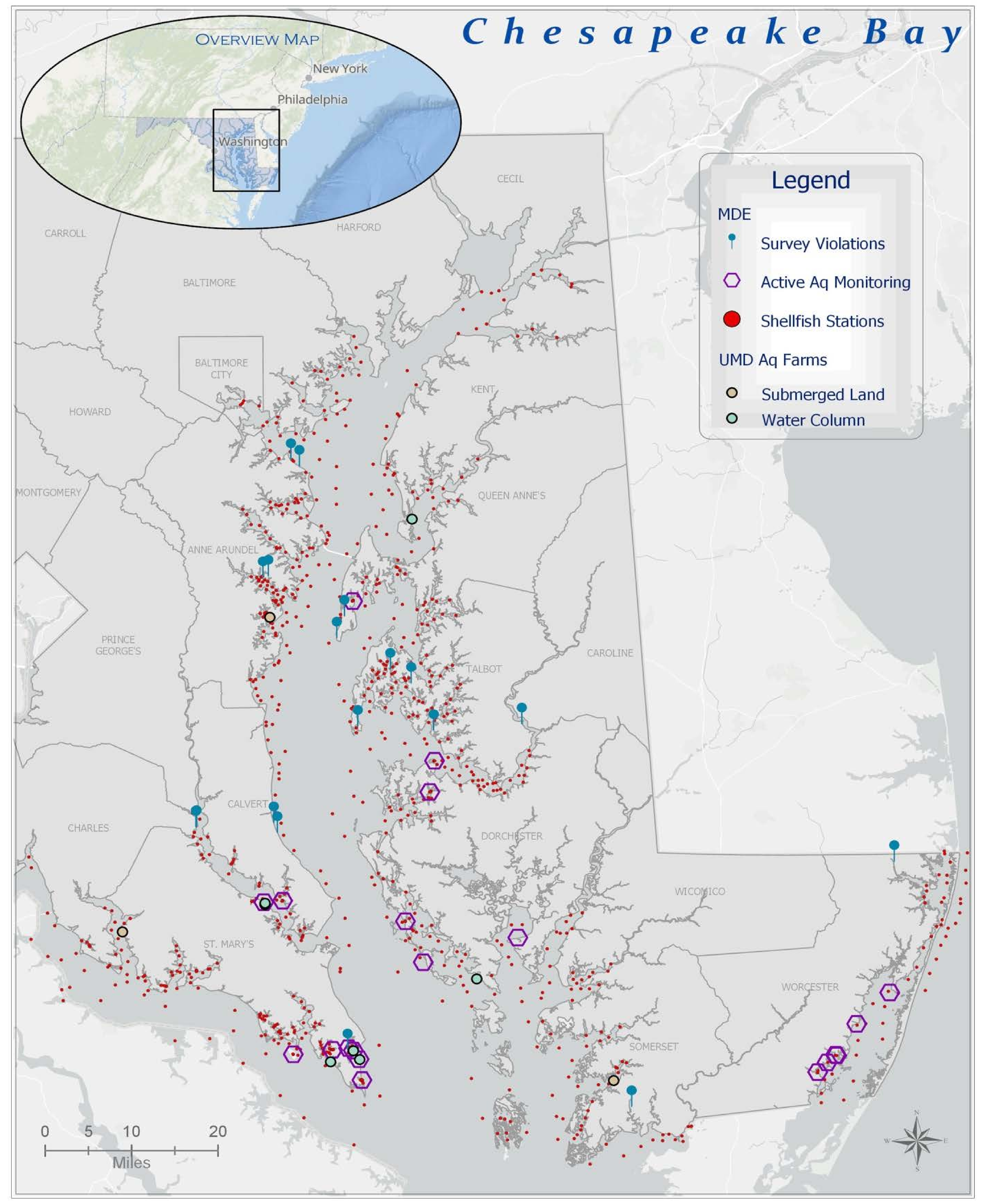
Shellfish aquaculture is a growing industry in the Chesapeake Bay. Resource managers need reliable information on a variety of water quality indicators at higher frequency than possible through field monitoring programs and at a higher level of detail than current satellite products provide. Many factors causing degraded water quality that impact human health are not currently discernable by traditional multispectral techniques. Hyperspectral imagery offers a new opportunity to detect phytoplankton communities associated with harmful algal blooms and biotoxin production. Together with resource managers at monitoring of sites around the bay from small boats, we are exploring remotely sensed optical proxies for the detection of poor water quality. Early warning by remote sensing could guide sampling and improve the efficiency of shellfish bed closures, ultimately improving health outcomes for humans and animals. Upcoming space-based hyperspectral measurements at various spatial, spectral and temporal scales make this a critical time for defining the needs of the aquaculture and resource management community to save lives, time, and money.

Parameter name	Poor Water Quality Threshold
Fecal coliform	> 14 MPN median per 100ml
Bacteriological *Escherichia coli*	> 410 count per 100ml
Dissolved oxygen	< 5 mg/l
Temperature	> 90ºF/32ºC
pH	< 6.5 or > 8.5
Turbidity	>150 nephelometer turbidity units
Color	> 75 platinum cobalt units
Water clarity	< 13% (tidal fresh)

***Table 1**. Maryland water quality criteria for shellfish harvesting (class II waters),* http://www.dsd.state.md.us/comar/comarhtml/26/26.08.02.03-3.htm, accessed 3.30.19

Method

Optical brighteners are water soluble chemicals added to laundry detergent to restore fabric whiteness (due to their fluorescing emission at 440 nm). Their detection in coastal waters is associated with sewage input. Several methods have been investigated to detect brighteners directly in natural waters [Dixon 2009; Poiger 1996]. However, brighteners and colored dissolved organic matter (CDOM) emit over a similar spectral range, thus it is necessary to separate the brightener signal from that of CDOM.



Credit: MDE/Ann McManus

***Figure 1.** Sites routinely monitored by MDE (blue pins), shellfish stations (red dots), and active aquaculture monitoring sites (purple hexagons).*

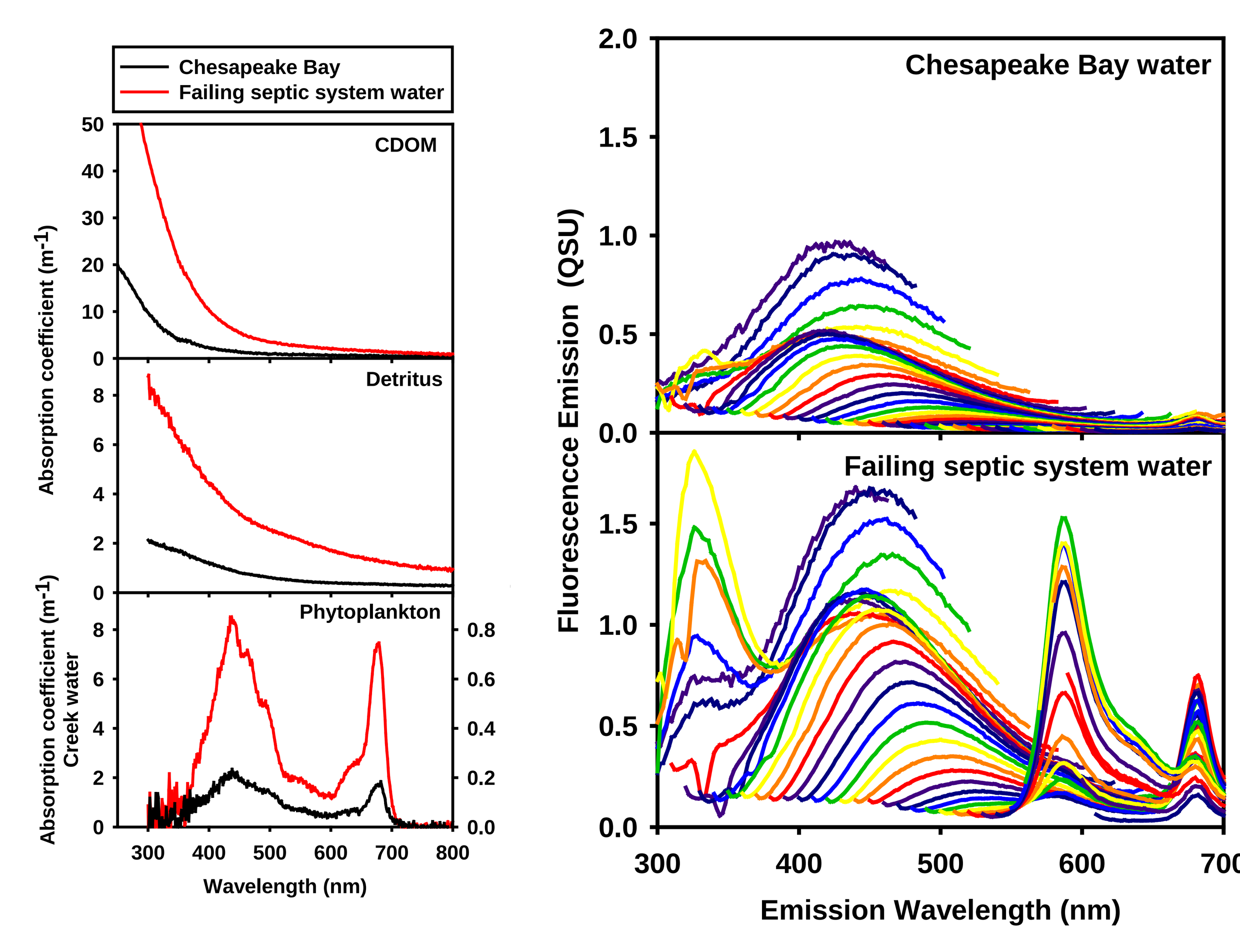


***Figure 2.** Absorption coefficient (m^{-1}) (left) and fluorescence emission (QSU) (right) of unfiltered water from the Chesapeake Bay and water near a failing septic system after heavy rain.*

Early Findings

Several physical parameters correlate with high fecal coliform counts (Table 1). During our initial study, we identified additional optical proxies corresponding to anthropogenic effluent:

1. Colored dissolved organic matter (CDOM) *(excitation >250 nm; emission >450 nm)*
2. Proteins *(excitation 280 nm; emission 305 nm, 350 nm)*
3. Phycoerythrins *(excitation 496 nm, 546 nm, 565 nm; emission 578 nm)*
4. Optical brighteners *(excitation 340 nm; emission 440 nm)*
5. F-ratios *(emission ratio 440/370 nm at single excitation, 340 nm)*

Next steps

- Equip shellfish monitoring vessels with flow-through instrumentation to monitor water quality continuously while underway. Continue analyzing optical, physical, and bacteriological properties of water flowing into the Bay from land to detect a unique *in situ* and remotely sensed spectral signature for sewage.
- While absorption spectroscopy has been widely used to remotely retrieve in-water optical properties, fluorescence spectroscopy is a promising new tool that is more sensitive and faster, thus allowing for continuous *in situ* (and aerial) monitoring of aquatic environments, providing a potential supplementary tool for early warning of water quality.

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Department of the Environment

University of Maryland 1856

Goddard Space Flight Center